

Modeling Cyanobacteria Movement in Milford Lake, Part II

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Background



- Research Funded by KDHE
 - Use computer modeling to develop a better understanding of cyanobacteria transport
 - Develop animations for different scenarios, varying:
 - Lake Level
 - Wind Conditions
 - Flow Rate



Background



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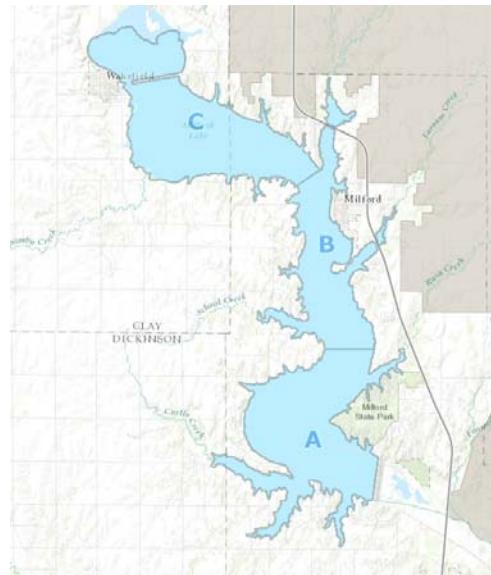
Background



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Background



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Background



- Two Projects

- 2016-17: 2D model of algae transport in Milford Zone C
 - 24 eight-day simulations
 - Project completed in summer 2017
- 2017-18: 2D model of algae transport in entire lake
 - 30 twenty-day simulations
 - Project is on schedule to complete in summer 2018

Model Description



- 2016-17: Research Model Developed at KU

- 2D hydrodynamics
 - Finite difference
 - Rectangular, regular mesh
 - Fully implicit
 - Parallelized
- Constituent transport
 - Sediment
 - Contaminant

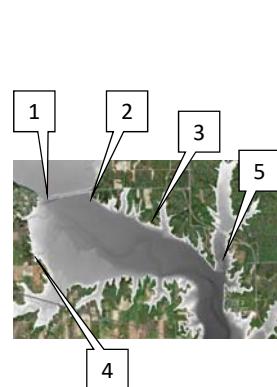


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2016-17 Project Results



Case	Bloom Location	Days 1 - 4		Days 5 - 8		Beginning Lake Level (ft)	Days 1 - 4		Days 5 - 8	
		Wind Dir. (from)	Wind Speed (mph)	Wind Dir. (from)	Wind Speed (mph)		Inflow (cfs)	Outflow (cfs)	Inflow (cfs)	Outflow (cfs)
1	1, 2, 3, 4	N	12	N	12	1144.4	25	25	25	25
2	1, 2, 3, 4	N	12	N	12	1144.4	2000	2000	2000	2000
3	1, 2, 3, 4	W	12	W	12	1144.4	25	25	25	25
4	1, 2, 3, 4	W	12	W	12	1144.4	2000	2000	2000	2000
5	1, 2, 5	S	12	N	12	1144.4	25	25	25	25
6	1, 2, 5	S	12	S	12	1144.4	25	2000	25	2000
7	1, 2, 5	S	12	N	12	1146.4	25	25	25	25
8	1, 2, 5	S	12	S	2	1144.4	25	25	25	25
9	1, 2, 5	S	2	N	20	1144.4	25	25	25	25
10	1, 2, 5	No Wind	0	No Wind	0	1144.4	25	25	25	25
11	1, 2, 5	No Wind	0	No Wind	0	1146.4	25	25	25	25
12	1, 2, 5	N	12	N	12	1144.4	25	25	25	25
13	1, 2, 5	N	12	N	12	1144.4	25	2000	25	2000
14	1, 2, 5	W	12	W	12	1144.4	25	25	25	25
15	1, 2, 5	W	12	W	12	1144.4	25	2000	25	2000
16	1, 2, 5	N	12	S	12	1144.4	25	25	25	25
17	1, 2, 5	N	12	W	12	1144.4	25	25	25	25
18	1, 2, 5	W	12	N	12	1144.4	25	25	25	25
19	1, 2, 5	W	12	S	12	1144.4	25	25	25	25
20	1, 2, 5	S	12	W	12	1144.4	25	25	25	25
21	1, 2, 5	S	12	N	12	1144.4	25	25	25	2000
22	1, 2, 5	S	12	S	12	1144.4	25	25	25	2000
23	1, 2, 5	S	12	N	12	1144.4	25	25	2000	25
24	1, 2, 5	S	12	S	12	1144.4	25	25	2000	25
25	1, 2, 5	S	12	N	12	1144.4	25	1500	25	25
26	1, 2, 5	S	12	S	12	1144.4	25	2000	25	25



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2016-17 Project Results



Simulations Sorted by Wind Direction				
Click on hyperlink to view simulation sets				
No Wind:	2			
Days 1 - 4				
	N	E	S	W
Days 5 - 8	4		6	1
	E			
	S	1	5	1
	W	1	1	4



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2016-17 Project Results



Case	Bloom Location (from ..)	Days 1 - 4		Days 5 - 8		Beginning Lake Level (ft)	Days 1 - 4		Days 5 - 8		Bloom Location
		Wind Dir.	Wind Speed (mph)	Wind Dir.	Wind Speed (mph)		Inflow (t/h)	Outflow (t/h)	Inflow (t/h)	Outflow (t/h)	
1	1, 2, 3,	3	12	N	12	1144.4	25	25	25	25	https://... https://... N/A N/A https://...
7	1, 2, 5	5	12	N	12	1144.4	25	25	25	25	https://... https://... N/A N/A https://...
9	1, 2, 5	5	2	N	20	1144.4	25	25	25	25	https://... https://... N/A N/A https://...
21	1, 2, 5	5	12	N	12	1144.4	25	25	25	2000	https://... https://... N/A N/A https://...
23	1, 2, 5	5	12	N	12	1144.4	25	25	2000	25	https://... https://... N/A N/A https://...
25	1, 2, 5	5	12	N	12	1144.4	25	1500	25	25	https://... https://... N/A N/A https://...

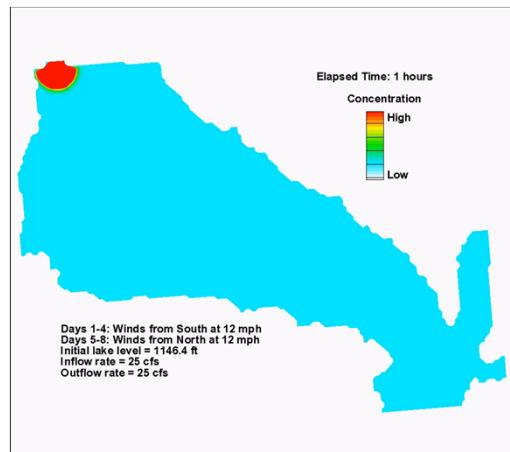
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2016-17 Project Results



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2016-17 Project Results

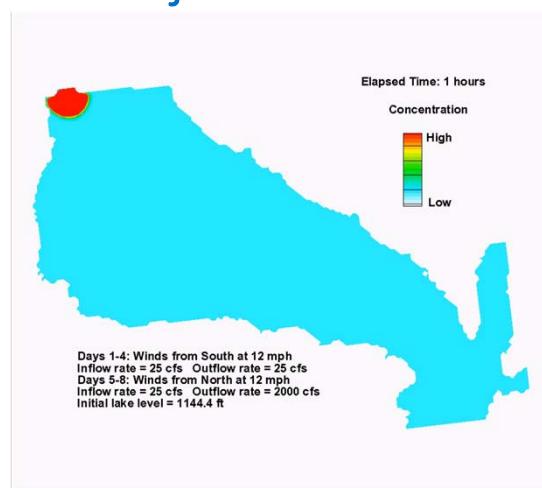


Case	Bloom Location (from ...)	Days 1 - 4		Days 5 - 8		Beginning Lake Level (ft)	Days 1 - 4		Days 5 - 8		Bloom Location
		Wind Dir.	Wind Speed (mph)	Wind Dir.	Wind Speed (mph)		Inflow (cfs)	Outflow (cfs)	Inflow (cfs)	Outflow (cfs)	
5	1, 2, 5	S	12	N	12	1144.4	25	25	25	25	https:// https:// N/A N/A https://
7	1, 2, 5	S	12	N	12	1146.4	25	25	25	25	https:// https:// N/A N/A https://
9	1, 2, 5	S	2	N	20	1144.4	25	25	25	25	https:// https:// N/A N/A https://
21	1, 2, 5	S	12	N	12	1144.4	25	25	25	2000	https:// https:// N/A N/A https://
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25	1, 2, 5	S	12	N	12	1144.4	25	1500	25	25	https:// https:// N/A N/A https://
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2016-17 Project Results



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2016-17 Project Results



Simulations Sorted by Wind Direction				
Click on hyperlink to view simulation sets				
No Wind:	2			
		Days 1 - 4		
	N	4		
	E		6	1
	S	1		
	W	1	1	4
Days 5 - 8				



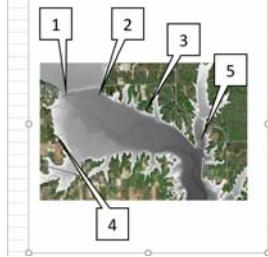
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2016-17 Project Results



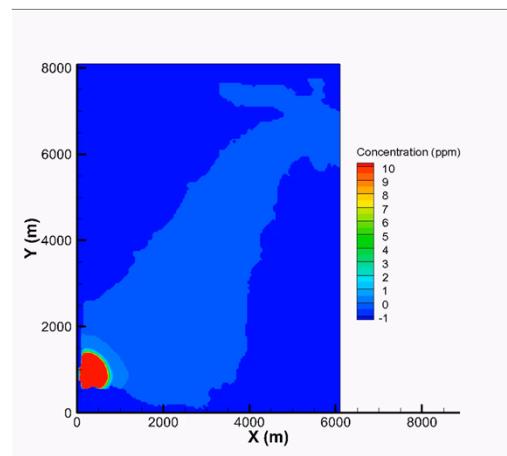
Case	Bloom Location (from)	Days 1 - 4		Days 5 - 8		Beginning Lake Level (ft)	Days 1 - 4		Days 5 - 8		Bloom location
		Wind Dir. (from)	Wind Speed (mph)	Wind Dir. (from)	Wind Speed (mph)		Inflow (cfs)	Outflow (cfs)	Inflow (cfs)	Outflow (cfs)	
3	1, 2, 3, 4	W	12	W	12	1144.4	25	25	25	25	https://x/ https://y/ https://z/ https://x/ NA
4	1, 2, 3, 4	W	12	W	12	1144.4	2000	2000	2000	2000	https://y/ https://z/ https://x/ https://y/ NA
14	1, 2, 3	W	12	W	12	1144.4	25	25	25	25	https://z/ https://x/ NA NA https://y/
15	1, 2, 3	W	12	W	12	1144.4	25	2000	25	2000	https://y/ https://z/ NA NA https://x/

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2016-17 Project Results



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Summary of 2016-17 Project



- What it does do
 - Builds a qualitative understanding of algal transport in Zone C
 - Evaluates a wide variety of wind and flow conditions
- Limitations
 - Limited to upper third of the lake
 - Simulation in 2D, not 3D
 - Treating algae as a conservative tracer



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Background



- Two Projects
 - 2016-17: 2D model of algae transport in Milford Zone C
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 - 2017-18: 2D model of algae transport in entire lake
 - 30 twenty-day simulations
 - Project is on schedule to complete in summer 2018

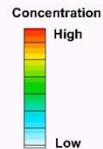


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Initial Results: Low Flow



Time: 0 hours



Wind from North at 12 mph
Initial lake level = 1144.4 ft
Inflow = Outflow = 25 cfs
Simulation time: 20 days

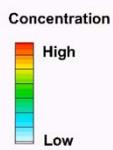


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Initial Results: High Flow



Time: 0 hours



Wind from North at 12 mph
Initial lake level = 1144.4 ft
Inflow = Outflow = 2000 cfs
Simulation time: 20 days



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2017-18 Project



- On track
 - 2D model is set up
 - Will begin developing the 30 scenarios
 - Simulation will be complete by summer



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2017-18 Project

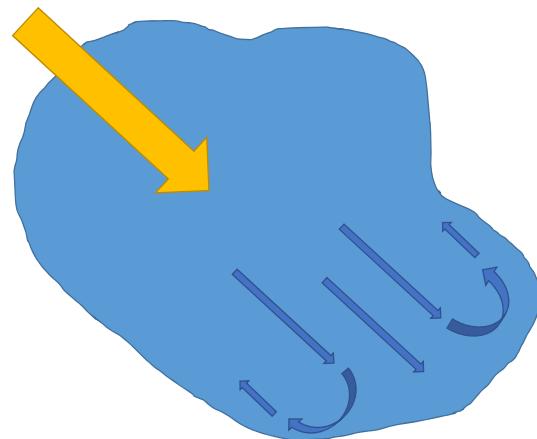


- What it does do
 - Builds a qualitative understanding of algal transport in entire lake
 - Evaluates a wide variety of wind and flow conditions
- Limitations
 - Simulation in 2D, not 3D
 - Treating algae as a conservative tracer



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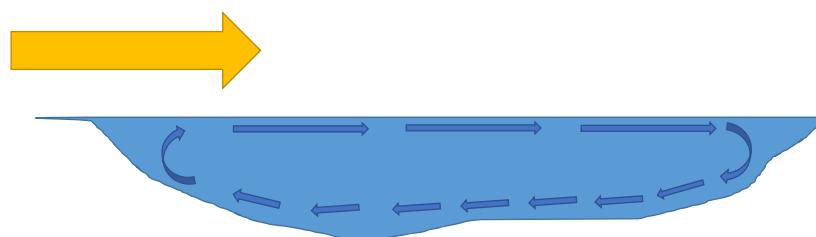
2D vs 3D



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2D vs 3D



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3D Model in Development

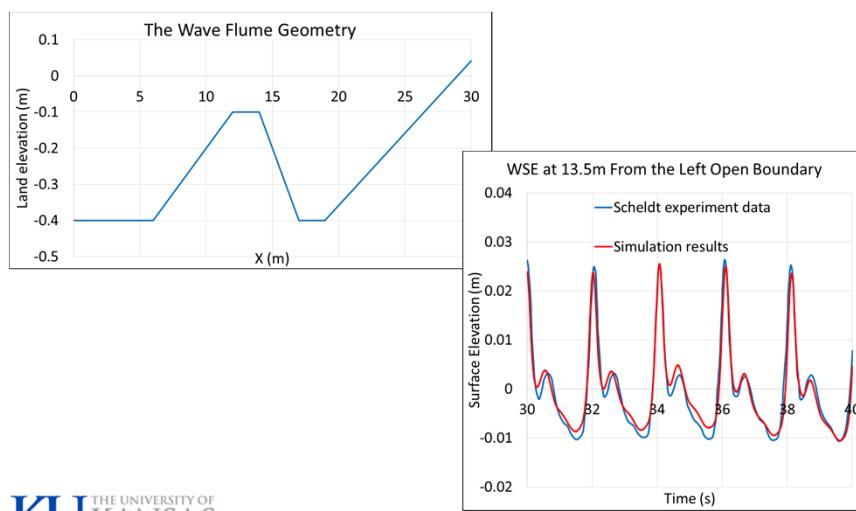


- 3D Model Development
 - 3D hydrodynamics
 - Finite difference
 - Rectangular, regular mesh
 - Fully implicit
 - Parallelized
 - Constituent transport
 - Sediment
 - Contaminant
 - Algae growth and decay
 - Nutrients
 - Varying buoyancy



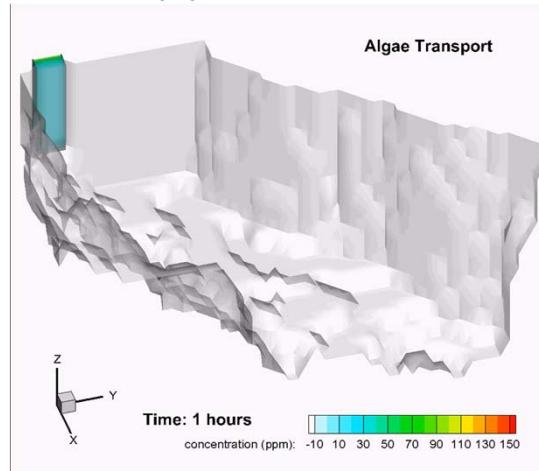
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3D Model Validation



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3D Model Applied to Zone C



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Summary



- 2016-17 Project Complete
 - Algal transport in Milford Lake, Zone C
 - 26 scenarios, 82 total animations
- 2017-18 Project On Track
 - Two test simulations complete
 - Ready to simulate 30 scenarios
- 3D Model in Development



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Questions?

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Z. Charlie Zheng, Ph.D. (zzheng@ku.edu)

